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(54) **INKJET RECORDING DEVICE**

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(57) **ABSTRACT**

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**B41J 2/19** (2006.01)

(52) **U.S. Cl.**

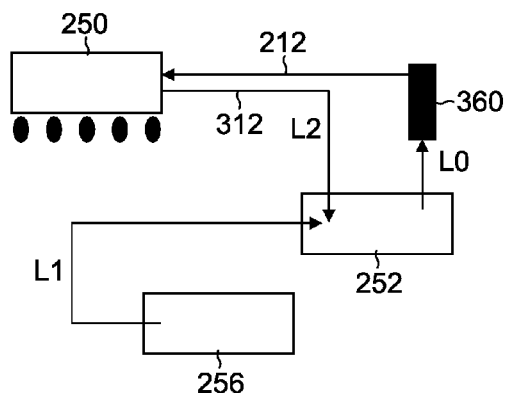
CPC ..... **B41J 2/17566** (2013.01); **B41J 2/175** (2013.01); **B41J 2/18** (2013.01); **B41J 2/19** (2013.01)

An inkjet recording device includes: a head; an ink tank which is connected with the head through a supply channel and a collection channel; a deaeration module which is provided on a side of the supply channel; a main tank; and a supply control unit which controls supply and collection of the ink, where: a supplement flow rate from the main tank to the ink tank is assumed as L1 (ml/sec), a consumption flow rate of ejection from the head is assumed as L2 (ml/sec), and, in the case of  $L1 < L2$ , print time limit n is calculated by equation:  $n \leq (\Delta T / L2) + [T_o / (L2 - L1)]$ ; and, when printing does not end within the print time limit n, the printing is interrupted and the ink is deaerated by circulating the ink.

**5 Claims, 6 Drawing Sheets**

(58) **Field of Classification Search**

USPC ..... 347/14, 11, 90, 89, 85, 86  
See application file for complete search history.



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**FIG. 1**

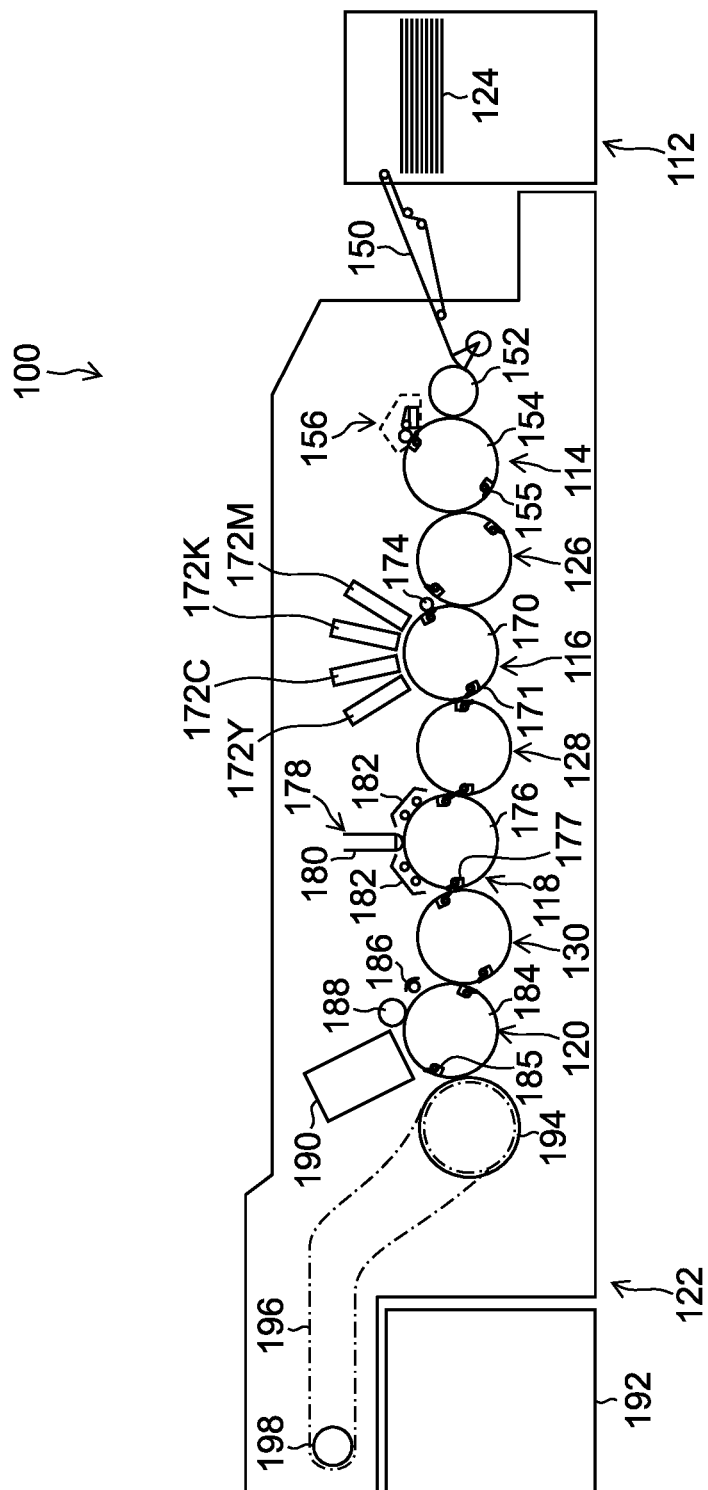


FIG. 2

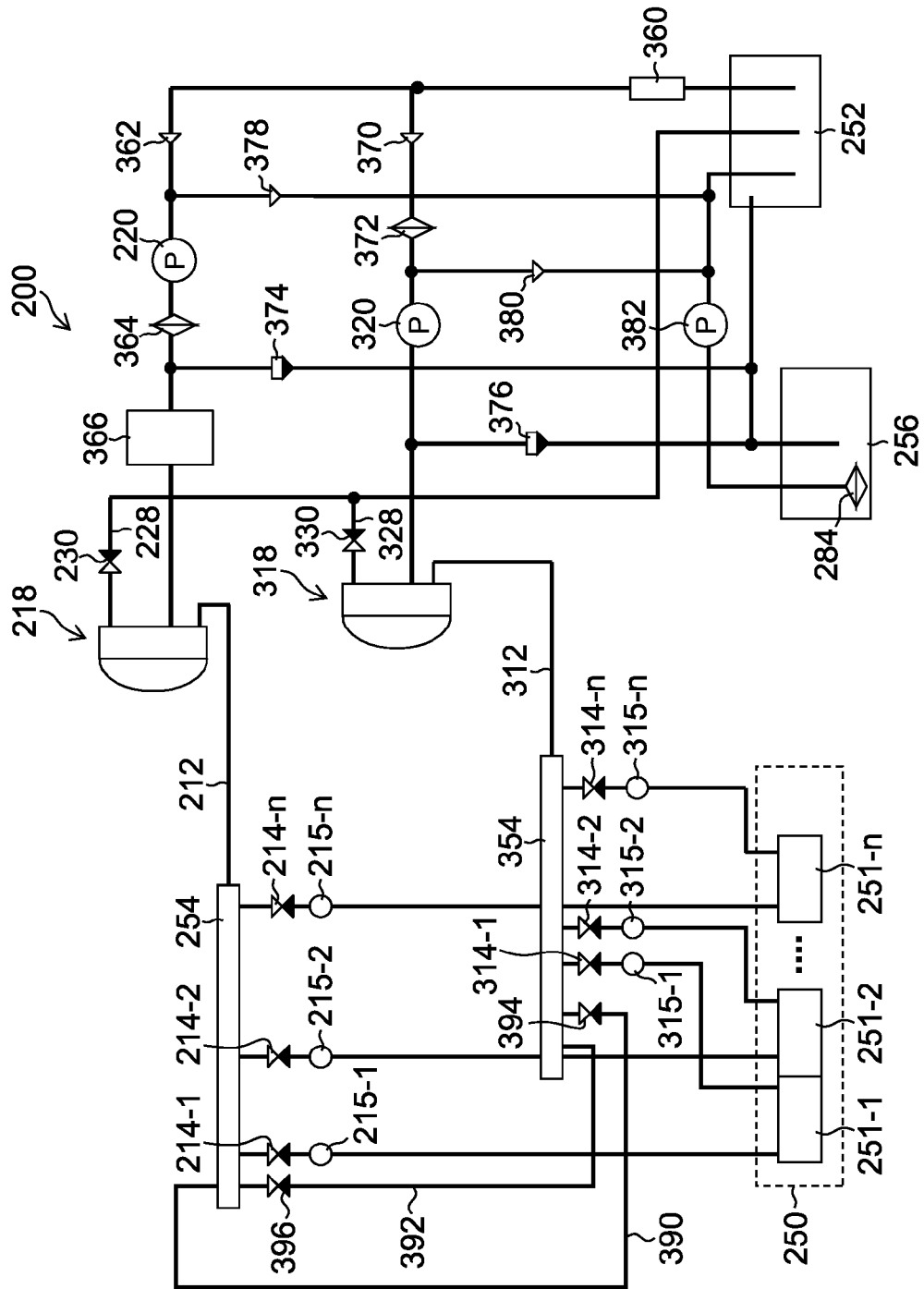


FIG.3

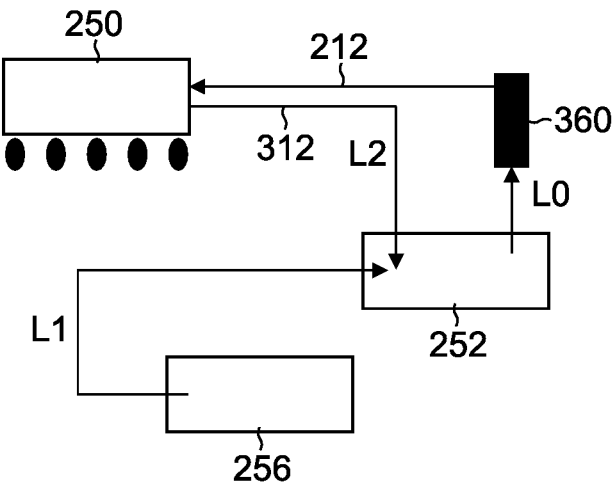
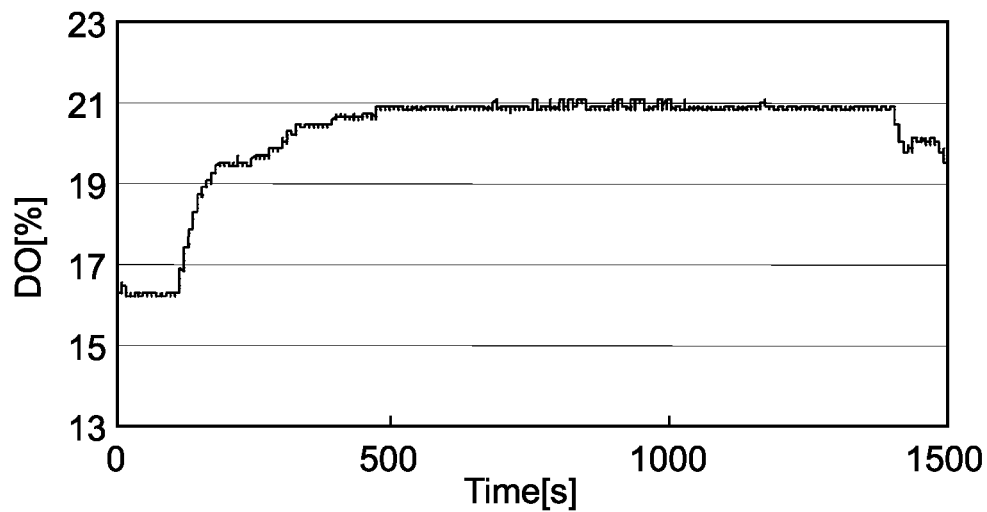
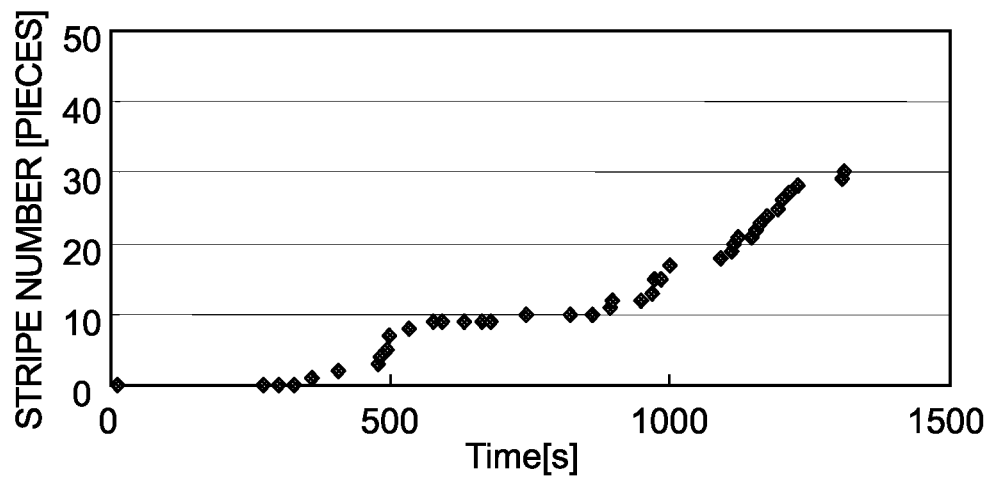


FIG.4A



RELATED ART

FIG.4B



RELATED ART

FIG. 5A

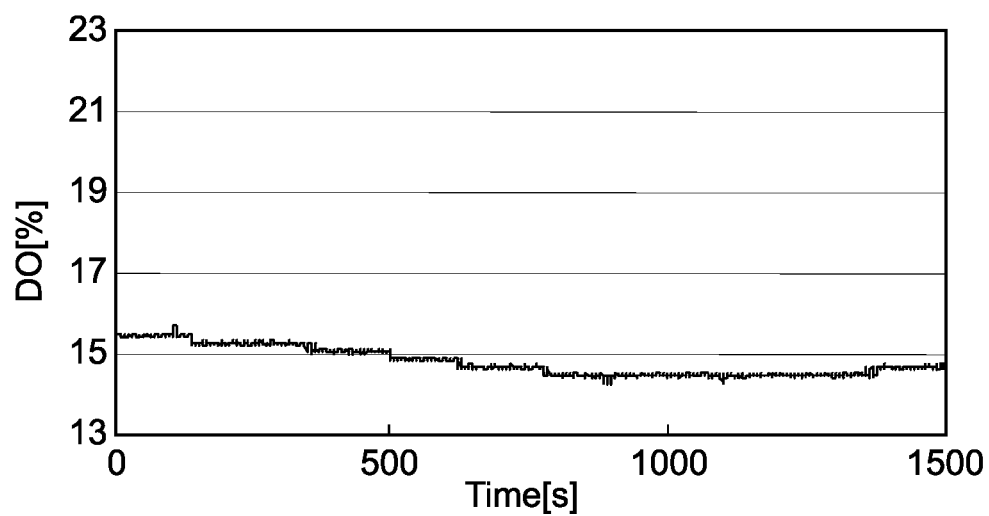


FIG. 5B

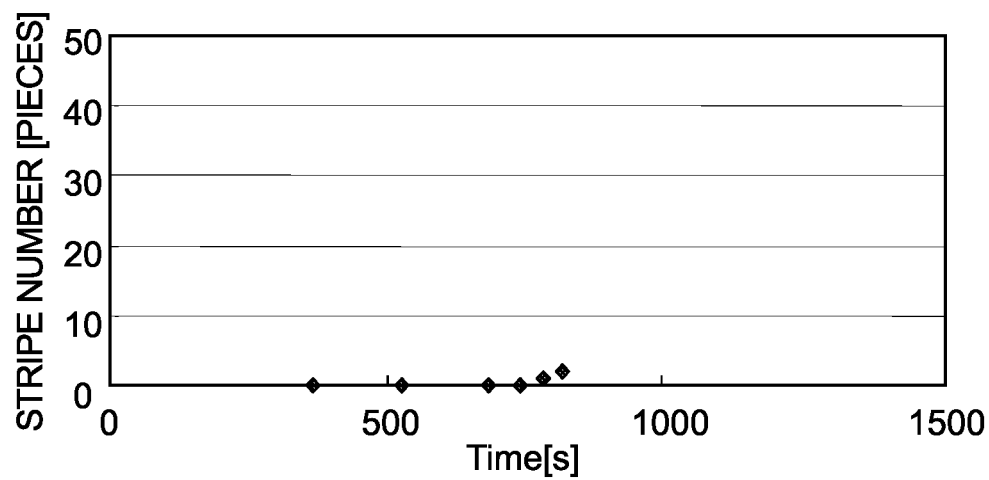
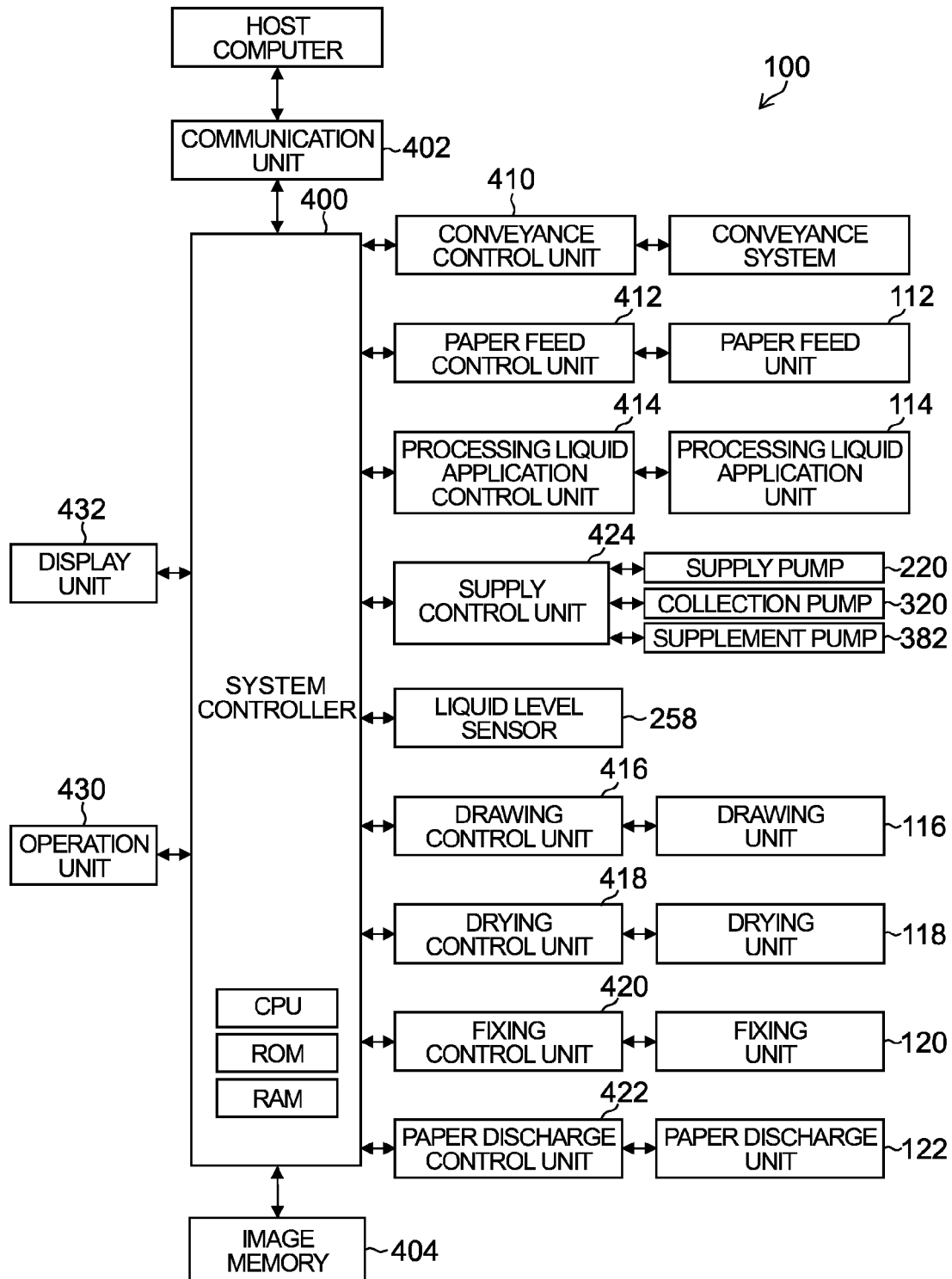


FIG. 6



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## INKJET RECORDING DEVICE

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a Continuation of PCT International Application No. PCT/JP2014/056297 filed on Mar. 11, 2014, which claims priority under 35 U.S.C §119(a) to Japanese Patent Application No. 2013-057593 filed on Mar. 21, 2013. Each of the above applications is hereby expressly incorporated by reference, in their entirety, into the present application.

## BACKGROUND OF THE INVENTION

## 1. Field of the Invention

The present invention relates to an inkjet recording device, and particularly relates to an inkjet recording device including a circulation channel that circulates in an ejection unit and storage unit of liquid.

## 2. Description of the Related Art

Recently, a demand for printing with a small number of copies has grown in the printing industry. Since it is necessary to make a plate in offset printing, there is a problem in respect of time and costs when printing with a small number of copies is performed. Therefore, inkjet recording of a single-pass system is suitably used.

However, in the single pass system, there is a fault that, when a nozzle that does not perform ejection or a nozzle with ejection bending exists, a stripe is remarkable in the lack part. As a factor to cause the stripe, air bubbles mixed in a head (the rise of a dissolved oxygen amount) are a large factor. By installing a deaeration module in a circuit to remove the air bubbles, the dissolved oxygen amount in ink is kept at a low level during circulation by the deaeration module. However, when deaerated ink is consumed by printing, non-deaerated ink is supplemented from a main tank and the dissolved oxygen amount during circulation increases.

Japanese Patent Application Laid-Open No. 11-334104 (PTL 1) listed below describes an inkjet printer that avoids defective printing by ink ejection instability by stopping printing when detecting that ink in an ink tank decreases to be equal to or less than a predetermined amount or by forcibly stopping printing when it is over a defined print number limit.

## SUMMARY OF THE INVENTION

However, the inkjet printer described in PTL 1 merely stops printing, and it is not discussed that a stripe does not occur in an image formed by the rise of a dissolved oxygen amount.

The present invention is made in view of such circumstances, and it is an object to provide an inkjet recording device that can form an image of high quality by maintaining the dissolved oxygen amount of ink during printing to a low level.

To achieve the object, the present invention provides an inkjet recording device including: an ejection head in which an ejection port to eject ink is formed; an ink tank which is connected with the ejection head through a supply channel and a collection channel and houses the ink supplied to the ejection head through the supply channel and collected from the ejection head through the collection channel; a deaeration module which is provided on a side of the supply channel and deaerates the ink; a main tank which is connected with the ink tank through a supplement channel and in which the ink supplied to the ink tank through the supplement channel is

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stored; a liquid level sensor which is provided in the ink tank and detects ink in the ink tank; a supply control unit which controls supply and collection of the ink; and a drawing control unit which controls ejection of the ink and performs image formation, where: the supply control unit supplements the ink from the main tank to the ink tank at supplement flow rate L1 (mL/sec) when the liquid level sensor detects that an ink amount in the ink tank is equal to or less than a lower limit value, and interrupts supplement of the ink when the ink amount in the ink tank becomes an upper limit value; a consumption flow rate of the ink ejected from the ejection head is assumed as L2 (mL/sec), an amount of the ink in the ink tank before a start of printing is assumed as T (mL), an ink amount of a lower limit value detected by the liquid level sensor in the ink tank is assumed as  $T_o$  (mL), a used amount up to detection in the liquid level sensor from amount T of the ink in the ink tank before the start of printing is assumed as  $\Delta T (=T-T_o)$  (mL), and, in a case of  $L1 < L2$ , print time limit n (sec) is calculated by equation (1),  $n \leq (\Delta T/L2) + [T_o/(L2-L1)] \dots (1)$ ; and, when printing does not end within the print time limit n, the printing is interrupted within the print time limit n, and the ink is deaerated by circulating the ink between the ink tank and the ejection head.

According to the present invention, when the consumption flow rate is assumed as L2 and the supplement flow rate from the main tank to the ink tank is assumed as L1, in the case of  $L1 < L2$ , the print time limit is calculated by abovementioned equation (1). The print time limit is calculated, and, in a case where printing exceeds this print time limit, printing is interrupted and deaeration is performed. Since deaerated ink is stored in the ink tank in the print time limit, the dissolved oxygen amount can be maintained at a low level as a whole in the ink tank even if non-deaerated ink is supplemented from the main tank, and therefore it is possible to suppress the occurrence of stripes in a formed image.

In a case where printing exceeds the print time limit n, since deaerated ink from the main tank is stored in the ink tank, a stripe is likely to occur in a formed image. Therefore, in the present invention, since printing is interrupted and ink is deaerated before this print time limit n is exceeded, it is possible to eject a function liquid in a state where the dissolved oxygen amount of the function liquid ejected from the ejection head is maintained at a low level. Therefore, it is possible to suppress a stripe in a formed image.

In the inkjet recording device according to another mode of the present invention, it is preferable that the consumption flow rate L2 is decided based on a formed image.

According to the inkjet recording device according to another mode of the present invention, by deciding the consumption flow rate L2 by the amount of ejection from the ejection head, it is possible to calculate the print time limit n before printing.

In the inkjet recording device according to another mode of the present invention, it is preferable that interruption of the printing is performed during a deaeration waiting time to complete deaeration of the ink.

According to the inkjet recording device according to another mode of the present invention, since printing is interrupted and printing restarts after the deaeration waiting time, it can be assumed that deaeration of ink in the ink tank is completed and ink of a small dissolved oxygen amount is provided, and therefore it is possible to suppress a stripe in a formed image.

In the inkjet recording device according to another mode of the present invention, it is preferable that, when the deaeration waiting time is assumed as  $T_d$  (sec), a circulation amount to circulate from the ink tank to the ink tank through the

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ejection head is assumed as  $L0$  (ml/sec), performance of the deaeration module is assumed as  $Dp$  (dimensionless parameter) and a total ink amount in the ink tank, the ejection head, the supply channel and the collection channel is assumed as  $V$  (ml), the deaeration waiting time is calculated by equation (2).

$$Td = V / (Dp \times L0) \quad (2)$$

According to the inkjet recording device according to another mode of the present invention, it is possible to calculate the deaerating waiting time by equation (2).

In the inkjet recording device according to another mode of the present invention, it is preferable that: a maintenance time to perform maintenance of the ejection head during the image formation is provided; and, by adjusting at least any one of supplement flow rate  $L1$  into the ink tank and ink amount  $T$  in the ink tank, the print time limit  $n$  is made longer than time for the image formation during the maintenance.

According to the inkjet recording device according to another mode of the present invention, by adjusting supplement flow rate  $L1$  and ink amount  $T$  in the ink tank of the initial state, it is possible to lengthen the print time limit  $n$ . By lengthening the print time limit  $n$  and setting it equal to or greater than the interval of image formation time during maintenance, it is possible to make the deaeration waiting time equal to the time for the maintenance of the ejection head. Therefore, in a case where the deaeration waiting time and the maintenance time are necessary, it is possible to shorten the total print time.

According to the inkjet recording device of the present invention, the number of papers on which printing is possible by deaerated ink and supplemented ink at the time of the image formation start, and, by performing deaeration during printing in a case where printing does not end, it is possible to form an image of high quality without the occurrence of stripes in the formed image.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is the entire configuration diagram of an inkjet recording device;

FIG. 2 is a block diagram illustrating a schematic configuration of a circulation-type ink supply device;

FIG. 3 is a schematic diagram that simplifies the circulation-type ink supply device illustrated in FIG. 2;

FIG. 4A is a graph diagram illustrating a change in a dissolved oxygen amount with respect to time by a printing method in the related art;

FIG. 4B is a graph diagram illustrating a change in the stripe number of an image formed by a printing method in the related art;

FIG. 5A is a graph diagram illustrating a change in a dissolved oxygen amount with respect to time by a printing method of the present embodiment;

FIG. 5B is a graph diagram illustrating a change in the stripe number of an image formed by a printing method of the present embodiment; and

FIG. 6 is a block diagram of a control system of an inkjet recording device.

### DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

In the following, preferable embodiments of the present invention are described according to the accompanying drawings.

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#### <<Entire Configuration of Inkjet Recording Device>>

First, an inkjet recording device to which a liquid discharge device of the present invention is applied is described. FIG. 1 is a configuration diagram illustrating the entire configuration of an inkjet recording device according to the present invention.

This inkjet recording device **100** is an inkjet recording device of an impression cylinder direct-drawing system to form a desired color image by depositing ink of multiple colors from inkjet heads **172M**, **172K**, **172C** and **172Y** to a recording medium **124** (which may be referred to as "paper" for sake of convenience) held to an impression cylinder (drawing drum **170**) of a drawing unit **116**, which is an image formation device of an on-demand type to which a two-liquid reaction (coagulation) system to apply a processing liquid (a coagulation treatment liquid here) on the recording medium **124** before ink is deposited, make the processing liquid and an ink liquid react to each other and perform image formation on the recording medium **124** is applied.

As illustrated in the figure, the inkjet recording device **100** includes a paper feed unit **112**, a processing liquid application unit **114**, the drawing unit **116**, a drying unit **118**, a fixing unit **120** and a paper discharge unit **122**.

(Paper Feed Unit)

The paper feed unit **112** is a mechanism that supplies the recording medium **124** to the processing liquid application unit **114**, and the recording medium **124** that is a sheet is layered in the paper feed unit **112**. A paper feed tray **150** is installed in the paper feed unit **112**, and the recording medium **124** is fed from this paper feed tray **150** to the processing liquid application unit **114** one by one.

In the inkjet recording device **100** of this example, multiple kinds of recording media **124** of different paper types or sizes (paper sizes) can be used as the recording medium **124**. Multiple paper trays (not illustrated) that classify and accumulate various kinds of recording media are installed in the paper feed unit **112**, a mode in which a paper that is fed to the paper feed tray **150** is automatically switched among these multiple paper trays is possible, and a mode in which an operator selects or exchanges a paper tray according to the necessity is possible. Here, a sheet (cut sheet) is used as the recording medium **124** in this example, but a configuration in which a continuous paper (roll paper) is cut into a necessary size and fed is possible.

(Processing Liquid Application Unit)

The processing liquid application unit **114** is a mechanism that applies a processing liquid to the recording surface of the recording medium **124**. The processing liquid includes a color material coagulant that coagulates a color material (pigment in this example) in ink applied in the drawing unit **116**, and separation of the color material and a solvent in the ink is promoted when this processing liquid contacts with the ink.

As illustrated in FIG. 1, the processing liquid application unit **114** includes a feeding cylinder **152**, a processing liquid drum **154** and an application device **156**. The processing liquid drum **154** is a drum that holds the recording medium **124** and performs rotation conveyance. The processing liquid drum **154** includes pawl-shaped holding means (gripper) **155** on the outer peripheral surface and can hold the front end of the recording medium **124** by sandwiching the recording medium **124** between the pawl of this holding means **155** and the peripheral surface of the processing liquid drum **154**. The processing liquid drum **154** may have an adsorption hole on the outer peripheral surface and connect with suction means for performing suction from the adsorption hole. By this

means, it is possible to closely hold the recording medium **124** on the peripheral surface of the processing liquid drum **154**.

On the outside of the processing liquid drum **154**, the application device **156** is installed so as to be opposite to the peripheral surface thereof. The application device **156** includes an application plate in which a processing liquid is stored, an anilox roller (measurement roller) of which part is dipped in the processing liquid of this application plate, and a rubber roller (application roller) that is subjected to pressure welding by the anilox roller and the recording medium **124** on the processing liquid drum **154** and transfers a measured processing liquid to the recording medium **124**. According to this application device **156**, it is possible to apply the processing liquid to the recording medium **124** while measuring it.

The recording medium **124** to which the processing liquid is applied in the processing liquid application unit **114** is passed from the processing liquid drum **154** to the drawing drum **170** of the drawing unit **116** through a middle conveyance unit **126**.

(Drawing Unit)

The drawing unit **116** includes the drawing drum (second conveyance body) **170**, a paper press roller **174** and the inkjet heads **172M**, **172K**, **172C** and **172Y**. Similar to the processing liquid drum **154**, the drawing drum **170** includes pawl-shaped holding means (gripper) **171** on the outer peripheral surface. The recording medium **124** fixed to the drawing drum **170** is conveyed such that the recording surface faces the outside, and ink is given from the inkjet heads **172M**, **172K**, **172C** and **172Y** to this recording surface.

It is preferable that each of the inkjet heads **172M**, **172K**, **172C** and **172Y** is assumed as a recording head (inkjet head) of an inkjet system of a full-line type with a length corresponding to the maximum width of an image formation region in the recording medium **124**. A nozzle array in which multiple nozzles for ink ejection are arranged over the entire width of the image formation region is formed on the ink ejection surface. Each of the inkjet heads **172M**, **172K**, **172C** and **172Y** is installed so as to extend in a direction orthogonal to the conveyance direction of the recording medium **124** (the rotation direction of the drawing drum **170**). When droplets of corresponding color ink are ejected from each of the inkjet heads **172M**, **172K**, **172C** and **172Y** to the recording surface of the recording medium **124** closely held on the drawing drum **170**, the ink contacts with a processing liquid applied beforehand to the recording surface of the processing liquid application unit **114**, and a color material (pigment) that disperses in the ink is coagulated to form a color material aggregate. By this means, a color material flow or the like on the recording medium **124** is prevented, and an image is formed on the recording surface of the recording medium **124**.

Here, a configuration with standard colors of CMYK (four colors) is exemplified in this example, but a combination of ink colors and the color number is not limited to the present embodiment, and a light shade ink, a deep ink and a special color ink may be added according to the necessity. For example, a configuration in which inkjet heads that eject light system ink such as light cyan and light magenta are added is possible, and the arrangement order of respective color heads is not especially limited.

The recording medium **124** on which an image is formed in the drawing unit **116** is passed from the drawing drum **170** to a drying drum **176** of the drying unit **118** through a middle conveyance unit **128**.

(Drying Unit)

The drying unit **118** is a mechanism that dries moisture included in a solvent separated by color material coagulant operation, and includes the drying drum **176** and a solvent drying device **178** as illustrated in FIG. 1.

Similar to the processing liquid drum **154**, the drying drum **176** includes pawl-shaped holding means (gripper) **177** on the outer peripheral surface and can hold the front end of the recording medium **124** by this holding means **177**.

The solvent drying device **178** includes multiple IR heaters **182** disposed in positions facing the outer peripheral surface of the drying drum **176**, and a hot air ejection nozzle **180** disposed between respective IR heaters **182**.

It is possible to realize various drying conditions by arbitrarily adjusting the temperature and air quantity of hot air blown from the hot air ejection nozzle **180** to the recording medium **124** and the temperature of respective IR heaters **182**.

Moreover, the surface temperature of the drying drum **176** is set to 50° C. or more. Drying is promoted by heating the back surface of the recording medium **124**, and it is possible to prevent image destruction at the time of fixing. Here, the upper limit of the surface temperature of the drying drum **176** is not especially limited, but it is preferable to be set to 75° C. or less (more preferably, 60° C. or less) from the viewpoint of the safety (prevention of burn by high temperature) of maintenance operation such as cleaning of ink attached to the surface of the drying drum **176**.

By holding the recording surface of the recording medium **124** so as to face the outside (that is, in a state where the recording surface of the recording medium **124** is curved so as to be a convex side) and performing rotation conveyance on the outer peripheral surface of the drying drum **176**, it is possible to prevent wrinkle and floating of the recording medium **124** from being generated and surely prevent drying unevenness due to these.

The recording medium **124** subjected to drying processing in the drying unit **118** is passed from the drying drum **176** to a fixing drum **184** of the fixing unit **120** through a middle conveyance unit **130**.

(Fixing Unit)

The fixing unit **120** includes the fixing drum **184**, a halogen heater **186**, a fixing roller **188** and an inline sensor **190**. Similar to the processing liquid drum **154**, the fixing drum **184** includes pawl-shaped holding means (gripper) **185** on the outer peripheral surface and can hold the front end of the recording medium **124** by this holding means **185**.

The recording medium **124** is conveyed by rotation of the fixing drum **184** such that the recording surface faces the outside, and this recording surface is subjected to preheating by the halogen heater **186**, fixing processing by the fixing roller **188** and inspection by the inline sensor **190**.

The halogen heater **186** is controlled at a predetermined temperature (for example, 180° C.). By this means, preheating of the recording medium **124** is performed.

The fixing roller **188** is a roller member to weld self-dispersion thermoplastic resin fine particles in ink by heating and pressurizing dried ink and film the ink, and it is configured so as to heat and pressurize the recording medium **124**. Specifically, the fixing roller **188** is disposed so as to be subjected to pressure welding with respect to the fixing drum **184**, and forms a nip roller with the fixing drum **184**. By this means, the recording medium **124** is sandwiched between the fixing roller **188** and the fixing drum **184**, nipped at a predetermined nip pressure (for example, 0.15 MPa) and subjected to fixing processing.

Moreover, the fixing roller **188** includes a heating roller that incorporates a halogen lamp in a metallic pipe such as

conductive aluminum of good thermal conductivity, and is controlled at a predetermined temperature (for example, 60° to 80° C.). Thermal energy equal to or greater than the Tg temperature of thermoplastic resin fine particles contained in ink (glass transition point temperature) is given by heating the recording medium **124** by this heating roller, and the thermoplastic resin fine particles are melted. By this means, push-in fixing is performed on the asperity of the recording medium **124**, the asperity of an image surface is subjected to leveling, and luster is obtained.

Moreover, a configuration in which only one fixing roller **188** is provided is adopted in the embodiment in FIG. 1, but a configuration in which a plurality of ones are provided according to the thickness of an image layer and the Tg characteristics of thermoplastic resin fine particles is possible.

Meanwhile, the inline sensor **190** is measurement means for measuring the check pattern, moisture amount, surface temperature and glossiness, and so on, of an image fixed to the recording medium **124**, and a CCD line sensor or the like is applied.

According to the fixing unit **120** configured as above, since thermoplastic resin fine particles in an image layer that is a thin layer formed in the drying unit **118** are heated and pressurized by the fixing roller **188** and melted, it can be anchored and fixed to the recording medium **124**. Moreover, when the surface temperature of the fixing drum **184** is set to 50° C. or more, drying is promoted by heating the back surface of the recording medium **124** held to the outer peripheral surface of the fixing drum **184**, and it is possible to prevent image destruction at the time of fixing and improve image strength by a temperature rise effect of image temperature.

Moreover, in a case where a UV-curable monomer is contained in ink, by irradiating UV to an image by a fixing unit including a UV irradiation lamp after moisture is sufficiently volatilized in a drying unit, it is possible to harden and polymerize the UV-curable monomer and improve the image strength.

(Paper Discharge Unit)

As illustrated in FIG. 1, the paper discharge unit **122** is installed after the fixing unit **120**. The paper discharge unit **122** includes a discharge tray **192**, and a transfer barrel **194**, a conveyance belt **196** and a stretching roller **198** are installed between this discharge tray **192** and the fixing drum **184** of the fixing unit **120** so as to touch these. The recording medium **124** is sent to the conveyance belt **196** by the transfer barrel **194** and discharged to the discharge tray **192**.

Moreover, in addition to the above-mentioned components, the inkjet recording device **100** of this example includes an ink storage/loading unit that supplies ink to each of the inkjet heads **172M**, **172K**, **172C** and **172Y** and means for supplying a processing liquid to the processing liquid application unit **114** though they are not illustrated, and it includes a head maintenance unit that performs cleaning (wiping, purge and nozzle suction of a nozzle surface, and so on) of each of the inkjet heads **172M**, **172K**, **172C** and **172Y**, a position detection sensor that detects the position of the recording medium **124** in a paper conveyance path and a temperature sensor that detects the temperature of each unit of the device, and so on.

<<Description of Circulatory System of Inkjet Head>>

Next, the circulatory system of an inkjet recording device is described. FIG. 2 is a block diagram illustrating the outline of a circulation-type ink supply device.

(Entire Configuration)

An ink supply device **200** illustrated in this figure includes a supply channel **212** and a collection channel **312**. A supply

sub-tank **218** is installed in the supply channel **212**, and a collection sub-tank **318** is installed in the collection channel **312**. The supply sub-tank **218** is communicated with an ink tank **252** through a supply pump **220** and a predetermined ink channel, and the collection sub-tank **318** is communicated with the ink tank **252** through a collection pump **320** and a predetermined ink channel.

A head **250** (ejection head) illustrated in FIG. 2 is a head having a structure in which n head modules **251-1**, **251-2**, . . . , **251-n** are connected, and the head modules **251** are communicated with the supply channel **212** through dampers **215-1**, **215-2**, . . . , **215-n** and supply valves **214-1**, **214-2**, . . . , **214-n** respectively, and communicated with the supply channel **212** through dampers **315-1**, **315-2**, . . . , **315-n** and supply valves **314-1**, **314-2**, . . . , **314-n**, respectively.

A supply-side manifold **254** is a temporary ink storage unit installed between the supply channel **212** and the head **250**, and a collection-side manifold **354** is a temporary ink storage unit installed between the collection channel **312** and the head **250**. The supply-side manifold **254** and the collection-side manifold **354** are communicated with each other by a first bypass channel **390** and a second bypass channel **392**, and the first and second bypass channels **390** and **392** include a first bypass channel valve **394** and a second bypass channel valve **396** respectively.

As for the supply pump **220** and the collection pump **320**, a tube pump is applied. The supply pump **220** controls the pressure (liquid supply amount) of the supply channel **212** that supplies ink from the ink tank (buffer tank) **252** to the head **250**, and the collection pump **320** controls the pressure (liquid supply amount) of the collection channel **312** that collects (circulates) ink from the head **250** to the ink tank **252**. As for the supply pump **220** and the collection pump **320**, it is possible to apply pumps having the same performance (capacity).

The supply pump **220** and the collection pump **320** rotate only in one direction in a period in which the head **250** stops operating (that is, in a period in which ink stably flows), and, when the internal pressure decreases in a period in which the head **250** performs ejection operation, the supply pump **220** increases the rotational speed and the collection pump **320** reverses and raises the internal pressure of the head **250**.

The supply sub-tank **218** has a structure divided into the liquid chamber and the air chamber by an elastic membrane having flexibility. When ink flows into the liquid chamber, the elastic membrane is transformed to the air chamber side according to the volume of the flowed ink. Meanwhile, since the volume of the ink flowed out from the liquid chamber does not vary, even if pressure fluctuation is caused in the supply channel **212**, the pressure fluctuation is controlled by the operation of the supply sub-tank **218**. That is, the supply sub-tank **218** has a pressure adjustment function that suppresses the internal pressure variation of the head **250** and the internal pressure variation of the supply channel **212** by pulsating flow by the operation of the supply pump **220**. Moreover, the liquid chamber is communicated with the ink tank **252** through a drain channel **228** and a drain valve **230**. Here, the collection sub-tank **318** has a configuration similar to the supply sub-tank **218** and is communicated with the ink tank **252** through a drain channel **328** and a drain valve **330**.

In the ink supply device **200** illustrated in FIG. 2, a deaeration module **360** and a one-way valve **362** to prevent the backward flow of ink are installed between the ink tank **252** and the supply pump **220**, and a filter **364** and a heat exchanger (cooling heating device) **366** are installed between the supply pump **220** and the supply sub-tank **218**. Ink sent from the ink tank **252** is subjected to deaeration processing by

the deaeration module 360, subjected to the removal of air bubbles and foreign objects by the filter 364, subjected to temperature adjustment processing by the heat exchanger 366 and thereafter sent to the supply sub-tank 218.

Moreover, a one-way valve 370 to prevent the backward flow of ink is installed between the deaeration module 360 and the collection pump 320 and a filter 372 is installed between them, and, even in a case where ink is sent from the ink tank 252 to the collection sub-tank 318, predetermined deaeration processing and filter processing are applied.

In addition, safety valves (relief valves) 374 and 376 are installed in the ink supply device 200, and, in a case where abnormality occurs in the supply pump 220 and the collection pump 320 and the internal pressures of the supply channel 212 and the collection channel 312 become greater than a predetermined value, the safety valves 374 and 376 operate and decrease the internal pressures of the supply channel 212 and the collection channel 312. Moreover, one-way valves 378 and 380 to prevent the backward flow of ink when the supply pump 220 and the collection pump 320 are reversely operated are installed.

In a main tank 256 illustrated in FIG. 2, ink supplied to the ink tank 252 is stored. When the amount of ink in the ink tank 252 decreases, a supplement pump 382 is operated and ink in the main tank 256 is sent to the ink tank 252. In the main tank 256, a filter 284 is internally installed. A liquid level sensor (not illustrated) is installed inside the ink tank 252, and, when ink in the ink tank 252 falls below the liquid level sensor, ink is supplied from the main tank 256 to the ink tank 252.

(Explanation of Circulation)

The ink supply device 200 having such a configuration operates the supply pump 220 and the collection pump 320, sets a differential pressure between the supply-side manifold 254 and the collection-side manifold 354, and circulates ink. For example, the supply pump 220 is normally operated to cause a negative pressure in the supply-side manifold 254 in a state where the supply valve 214 and the collection valve 314 are opened, while, when the collection pump 320 is reversely operated to cause a more negative pressure in the collection-side manifold 354 than the supply side, it is possible to flow ink from the supply-side manifold 254 to the collection-side manifold 354 through the head 250 and moreover circulate ink through the collection channel 312 and the collection sub-tank 318, and so on.

When the ink is circulated, the second bypass channel valve 396 installed in the second bypass channel 392 may be opened, and the supply-side manifold 254 and the collection-side manifold 354 may be communicated with each other through the second bypass channel 392. Here, if the bypass channels 390 and 392 have a diameter in which pressure loss is not caused at the time of pressurization, any one of them may be included.

<<Description of Ink Supply Control at Image Formation>>

#### First Embodiment

Next, ink supply control at image formation is described. FIG. 3 is a schematic diagram that illustrates by simplifying illustrates the ink circulation channel illustrated in FIG. 2. As mentioned above, in the present embodiment, ink is supplied from the ink tank 252 to the head 250, and ink that is not ejected is collected and returned to the ink tank 252. Moreover, ink decreased by the ejection is supplemented from the main tank 256.

It is preferable that ink whose dissolved oxygen amount in the ink is maintained at a low level is used as ink used for image formation. By using the ink whose dissolved oxygen

amount is maintained at a low level, it is possible to suppress a stripe of a formed image and form an image of high quality.

In the initial state before image formation, ink filled in the ink tank 252 passes through the supply channel 212, and, by returning it from the collection channel 312 to the ink tank 252 through the deaeration module 360, a supply-side manifold 254, bypass channels 390 and 392 and the collection-side manifold 354, the deaeration of ink is performed. That is, the dissolved oxygen amount in the ink is maintained at a low level around 15%.

In the initial state (before printing starts), storage for ink tank capacity margin T (ml) is performed in the ink tank 252. When printing starts, ink is supplied from the ink tank 252 to the head 250, and the ink is ejected by the head 250. When printing proceeds, ink in the ink tank 252 is consumed and the amount of ink in the ink tank 252 falls below lower limit value  $T_0$  in the ink tank 252 (when it is consumed by  $\Delta T$ ), ink is supplemented at a constant flow rate from the main tank 256 into the ink tank 252. Detection of ink amount  $T_0$  in the ink tank 252 to which ink is supplied is performed by the liquid level sensor.

When the supplement flow rate of ink from the main tank 256 to the ink tank 252 at this time is assumed as  $L_1$  (ml/sec) and the average consumption flow rate according to printing is assumed as  $L_2$  (ml/sec), since the supplement flow rate from the main tank 256 to the ink tank 252 is greater than the consumption amount of ink in the ink tank 252 in the case of  $L_1 > L_2$ , the ink amount in the ink tank 252 increases and the supplement of ink from the main tank 256 stops at upper limit value  $T_{max}$  in the ink tank 252. To eject ink from the head 250, deaeration is performed in the deaeration module 360 when ink is supplied and collected, and, since deaerated ink is stored in the ink tank 252, it is possible to perform printing by ink of a small dissolved oxygen amount.

Next, the case of  $L_1 < L_2$  is described. In this case, since the supplement flow rate from the main tank 256 to the ink tank 252 is less than the consumption amount of ink, ink in the ink tank 252 gradually decreases from  $T_0$  at which the supply of ink from the main tank 256 starts. Therefore, since the amount of ink supplemented from the main tank 256 increases, the ink in the ink tank 252 gradually becomes ink of a large dissolved oxygen amount. Since an image in which a stripe occurs is provided when printing is performed with such ink of a large dissolved oxygen amount, print time limit n is provided in the present embodiment, and, by interrupting printing and deaerating ink in the ink tank 252 in a case where this print limit time n is exceeded in the printing, the dissolved oxygen amount of ink in the ink tank 252 is suppressed to a low level.

Print time limit n is calculated by the following equation.

$$n \approx (\Delta T / L_2) + [T_0 / (L_2 - L_1)] \quad (1)$$

Here, consumption flow rate  $L_2$  denotes an average consumption flow rate in an image formation time, and it can be calculated before image formation, on the basis of a formed image. Moreover, supplement flow rate  $L_1$  from the main tank 256 denotes a fixed rate of supply from the main tank 256 when the liquid level sensor installed in the ink tank 252 finds that the ink amount in the ink tank 252 falls below lower limit value  $T_0$ .

In equation (1),  $(\Delta T / L_2)$  designates a print time before the supplement of ink from the main tank 256 to the ink tank 252 starts.  $[T_0 / (L_2 - L_1)]$  designates a print time until  $T_0$  is consumed after supplement from the main tank 256 to the ink tank 252 starts. That is, equation (1) indicates time to consume ink in the ink tank 252 in the initial state before printing starts. When at least sufficiently deaerated ink of the initial state is included in ejected ink, it can be assumed that the

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deaeration degree of ink in the ink tank is within a predetermined range (it is preferable to be 15% or less, and it is more preferable to be 9% or less), and it is possible to form an image in which a stripe is less likely to occur. Moreover, by providing print time limit  $n$  that satisfies equation (1), in the initial state, it is possible to interrupt printing in a state where ink exists in the ink tank 252. Therefore, since it is possible to interrupt printing in a state where the dissolved oxygen amount is maintained at a low level, it is possible to form a high-quality image in which the occurrence of a stripe of a formed image is suppressed.

Moreover, in equation (1), time required to exhaust ink in the ink tank 252 of the initial state is assumed to be print time limit  $n$ , but it is preferable to interrupt printing in a state where initial ink of a predetermined amount remains. It is preferable that the amount of ink in the ink tank 252 at the time of interruption of printing is 20% of the capacity of the ink tank 252, and it is more preferable that it is 30%.

In a case where print time limit  $n$  calculated by equation (1) is exceeded, deaeration is performed during printing. A deaeration waiting time when deaeration is performed is set to be equal to or greater than the time to complete the deaeration. Deaeration waiting time  $T_d$  (sec) can be calculated by following equation (2). When circulation amount  $L_0$  (ml/sec) and deaeration module performance  $D_p$  (dimensionless) are assumed and total ink amount  $V$  (ml) in the ink tank 252, the head 250, the supply channel 212 and the collection channel 312 is assumed, it is as follows:

$$T_d = V / (D_p L_0) \quad (2)$$

By assuming the deaeration waiting time to be equation (2), it is possible to perform deaeration of ink in the ink tank 252. The deaeration is performed through the deaeration module 360, and it is performed by making ink in the ink tank 252 circulate in the head 250. As for the circulation of ink, the deaeration can be substantially finished by performing the circulation twice, and, for example, it can be finished in about three minutes.

## Second Embodiment

Next, ink supply control at image formation according to the second embodiment is described. By increasing supplement flow rate  $L_1$  from the main tank 256 to the ink tank 252 and an amount for ink tank capacity margin  $T$ , it is possible to lengthen print time limit  $n$ . By lengthening the time of print time limit  $n$ , it is possible to set the deaeration waiting time to the same time as the maintenance time between print jobs. By setting the deaeration waiting time to the same time as the maintenance time between print jobs, it is possible to decrease the total time of printing.

Moreover, print time limit  $n$  can be changed by changing the position of the liquid level sensor, that is, the amount of  $T_0$ . By setting the position of the liquid level sensor to be high, since it is possible to supplement ink from the main tank in the early stage after printing starts, it is possible to lengthen print time limit  $n$ .

## Example

FIGS. 4A to 5B are diagrams illustrating the relationship between a change in the dissolved oxygen amount and the number of stripes in the present embodiment and the related art. FIG. 4A is a graph illustrating a change in the dissolved oxygen amount by printing in the related art, and FIG. 4B illustrates a change in the number of stripes with respect to FIG. 4A. Moreover, FIG. 5A illustrates a change in the dis-

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solved oxygen amount by printing in the present embodiment, and FIG. 5B illustrates a change in the number of stripes with respect to FIG. 5A.

As illustrated in FIGS. 4A and 4B, the dissolved oxygen amount increases when printing continues in the related art. It is possible to confirm that the number of stripes in a printed image increases according to an increase in the dissolved oxygen amount. According to FIGS. 4A and 4B, it is possible to confirm that the number of stripes increases when the dissolved oxygen amount is 20% or more.

By contrast with this, in the present invention, printing is interrupted with print time limit  $n$  as an upper limit such that ink of a large dissolved oxygen amount, which is supplied from the main tank 256, is not used for image formation. Therefore, as illustrated in FIG. 5A, it is possible to suppress an increase in the dissolved oxygen amount. By suppressing an increase in the dissolved oxygen amount, as illustrated in FIG. 5B, it is possible to confirm that the number of stripes in a formed image decreases and an image of high quality can be formed.

<<Control System>>

FIG. 6 is a block diagram illustrating the schematic configuration of a control system of the inkjet recording device 100 of the present embodiment.

As illustrated in the figure, the inkjet recording device 100 includes a system controller 400, a communication unit 402, an image memory 404, a conveyance control unit 410, a paper feed control unit 412, a processing liquid application control unit 414, a drawing control unit 416, a drying control unit 418, a fixing control unit 420, a paper discharge control unit 422, an operation unit 430 and a display unit 432.

The system controller 400 functions as control means for controlling each unit of the inkjet recording device 100 in an integral manner and functions as operation means for performing various kinds of operation processing. This system controller 400 includes a CPU, a ROM and a RAM, and performs operation according to a predetermined control program. The ROM includes a control program executed by this system controller 400 and various kinds of data required for control.

The communication unit 402 includes a necessary communication interface, and transmits and receives data between the communication interface and a connected host computer.

The image memory 404 functions as temporary storage means of various kinds of data including image data, and reads and writes data through the system controller 400. Image data imported from the host computer through the communication unit 402 is stored in this image memory 404.

The conveyance control unit 410 controls the conveyance system of a recording medium in the inkjet recording device 100. That is, it controls the drive of the feeding cylinder 152 and the processing liquid drum 154 in the processing liquid application unit 114, the drawing drum 170 in the drawing unit 116, the drying drum 176 in the drying unit 118 and the fixing drum 184 in the fixing unit 120, and controls the drive of the middle conveyance units 126, 128 and 130.

The conveyance control unit 410 controls a conveyance system according to an instruction from the system controller 400, and performs control such that the recording medium 124 is conveyed from the paper feed unit 112 to the paper discharge unit 122 without delay.

The paper feed control unit 412 controls the paper feed unit 112 according to an instruction from the system controller 400 and performs control such that the recording medium 124 is sequentially fed one by one without overlap.

The processing liquid application control unit 414 controls the processing liquid application unit 114 according to an

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instruction from the system controller **400**. Specifically, the drive of the application device **156** is controlled such that a processing liquid is applied to a recording medium conveyed by the processing liquid drum (impression cylinder) **154**.

The drawing control unit **416** controls the drawing unit **116** according to an instruction from the system controller **400**. Specifically, the drive of the inkjet heads **172M**, **172K**, **172C** and **172Y** is controlled such that a predetermined image is recorded in a recording medium conveyed by the drawing drum **170**. Moreover, printing is interrupted before print time limit  $n$  passes.

The supply control unit **424** controls the drive of the supply pump **220** and the collection pump **320**, supplies ink from the ink tank **252** to the inkjet heads **172M**, **172K**, **172C** and **172Y**, and collects ink into the ink tank **252**. Moreover, ink is circulated through the supply channel **212** and the collection channel **312** when the deaeration of ink in the ink tank **252** is performed.

Moreover, the supplement pump **382** is controlled on the basis of a liquid level sensor **258** installed in the ink tank **252**. The supplement pump **382** is driven when the liquid level of ink in the ink tank **252** becomes equal to or less than a set lower limit value, and ink is supplemented from the main tank **256**. Moreover, when the liquid level of ink in the ink tank **252** becomes a set upper limit value, the drive of the supplement pump **382** is stopped and the supplement of ink is discontinued.

The drying control unit **418** controls the drying unit **118** according to an instruction from the system controller **400**. Specifically, it controls the drive of the solvent drying device **178** such that the recording medium **124** conveyed by the drying drum **176** is dried by an IR heater **182** and the hot air ejection nozzle **180**.

The fixing control unit **420** controls the fixing unit **120** according to an instruction from the system controller **400**. Specifically, it controls the drive of the halogen heater **186** and the fixing roller **188** such that a recording medium conveyed by the fixing drum **184** is heated and pressurized. Moreover, it controls the operation of the inline sensor **190** such that a fixed image is read.

The paper discharge control unit **422** controls the paper discharge unit **122** according to an instruction from the system controller **400**. Specifically, it controls the drive of the transfer barrel **194**, the conveyance belt **196** and the stretching roller **198**, and so on, and performs control such that the recording medium **124** is stacked in the discharge tray **192**.

The operation unit **430** includes necessary operation means (for example, an operation button, a keyboard and a touch panel, and so on), and outputs operation information input from the operation means to the system controller **400**. The system controller **400** performs various kinds of processing according to the operation information input from this operation unit **430**.

The display unit **432** includes a necessary display device (for example, an LCD panel, and so on), and displays necessary information on the display device according to an instruction from the system controller **400**.

As mentioned above, image data recorded in the recording medium **124** is imported in the inkjet recording device **100** from the host computer through the communication unit **402**. The imported image data is stored in the image memory **404**. The system controller **400** performs necessary signal processing on the image data stored in this image memory **404** and generates dot data. Further, it controls the drive of respective inkjet heads **172M**, **172K**, **172C** and **172Y** of the drawing unit **116** according to the generated dot data, and records an image that shows the image data in a paper.

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The dot data is generated by generally performing color conversion processing and halftone processing on the image data. The color conversion processing is processing to convert image data expressed by sRGB or the like (for example, RGB 8-bit image data) into ink amount data of each color of ink used in the inkjet recording device **100** (in this example, conversion into ink amount data of each color of M, K, C and Y). The halftone processing is processing to perform processing such as error diffusion on the ink amount data of each color generated by the color conversion processing and convert it into dot data of each color.

The system controller **400** generates the dot data of each color by performing the color conversion processing and the halftone processing on image data. Further, by controlling the drive of a corresponding inkjet head according to the generated dot data of each color, an image shown by the image data is recorded in a paper.

What is claimed is:

1. An inkjet recording device comprising:

an ejection head in which an ejection port to eject ink is formed;

an ink tank which is connected with the ejection head through a supply channel and a collection channel and houses the ink supplied to the ejection head through the supply channel and collected from the ejection head through the collection channel;

a deaeration module which is provided on a side of the supply channel and deaerates the ink;

a main tank which is connected with the ink tank through a supplement channel and in which the ink supplied to the ink tank through the supplement channel is stored;

a liquid level sensor which is provided in the ink tank and detects ink in the ink tank;

a supply control unit which controls supply and collection of the ink; and

a drawing control unit which controls ejection of the ink and performs image formation, wherein:

the supply control unit supplements the ink from the main tank to the ink tank at supplement flow rate  $L1$  (ml/sec) when the liquid level sensor detects that an ink amount in the ink tank is equal to or less than a lower limit value, and the supply control unit interrupts supplement of the ink when the ink amount in the ink tank becomes an upper limit value;

a consumption flow rate of the ink ejected from the ejection head is assumed as  $L2$  (ml/sec), an amount of the ink in the ink tank before a start of printing is assumed as  $T$  (ml), an ink amount of a lower limit value detected by the liquid level sensor in the ink tank is assumed as  $T_0$  (ml), a used amount up to detection in the liquid level sensor from amount  $T$  of the ink in the ink tank before the start of printing is assumed as  $\Delta T (=T-T_0)$  (ml), and, in a case of  $L1 < L2$ , print time limit  $n$  (sec) is calculated by equation (1),

$$n \leq (\Delta T / L2) + [T_0 / (L2 - L1)] \quad (1); \text{ and}$$

when printing does not end within the print time limit  $n$ , the printing is interrupted within the print time limit  $n$ , and the ink is deaerated by circulating the ink between the ink tank and the ejection head.

2. The inkjet recording device according to claim 1, wherein the consumption flow rate  $L2$  is decided based on a formed image.

3. The inkjet recording device according to claim 1, wherein interruption of the printing is performed during a deaeration waiting time to complete deaeration of the ink.

4. The inkjet recording device according to claim 3, wherein, when the deaeration waiting time is assumed as  $T_d$  (sec), a circulation amount to circulate from the ink tank to the ink tank through the ejection head is assumed as  $L_0$  (ml/sec), performance of the deaeration module is assumed as  $D_p$  and a total ink amount in the ink tank, the ejection head, the supply channel and the collection channel is assumed as  $V$  (ml), the deaeration waiting time is calculated by equation (2)

$$T_d = V / (D_p \times L_0) \quad (2)$$

5. The inkjet recording device according to claim 1, wherein:

a maintenance time to perform maintenance of the ejection head during the image formation is provided; and by adjusting at least any one of supplement flow rate  $L_1$  in the ink tank and ink amount  $T$  in the ink tank, the print time limit  $n$  is made longer than time for the image formation during the maintenance.

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